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BURNING STEAM SIZES OF ANTHRACITE

WITH OR WITHOUT ADMIXTURE OF SOFT COAL

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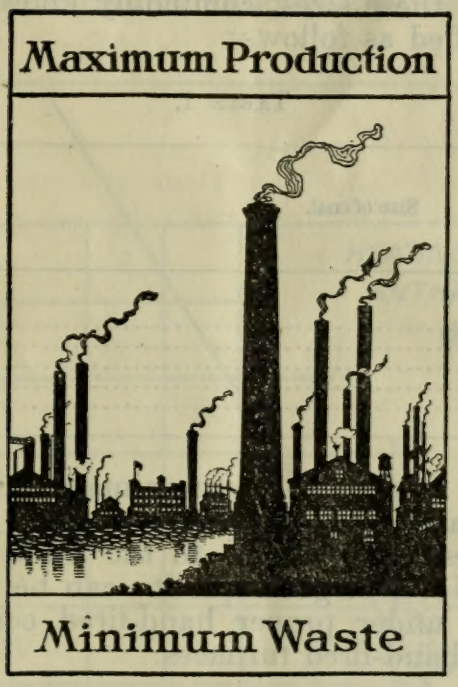


One of the most effective means of promoting fuel economy consists, frequently, in the substitution of a cheaper for a more expensive fuel. This bulletin describes briefly what modifications of furnace design and operation may be made in order to insure efficiency in burning mixtures of antharcite and soft coal in furnaces designed for one or the other of these two varieties of coal.

BURNING STEAM SIZES OF ANTHRACITE WITH OR WITHOUT ADMIXTURE OF SOFT COAL.

Based on an article by WILLIAM P. FREY, Fuel Engineer.

This bulletin describes, in the simplest terms, how to burn steam-size anthracite, or mixtures of this, with soft coal so as to get the most steam from the least fuel.

While the essential difference between the burning of anthracite and the burning of soft coal consists, in the case of anthracite in the use of a somewhat smaller volume of air per pound of fuel and a stronger draft, slight alterations in the method of firing and in the furnace, designed for one or the other fuel, are also necessary in case mixtures of soft and anthracite coal are used.

Just what volume of air and what strength of draft must be used to burn any particular fuel in any given furnace can only be determined by actual trial and, being once determined, must be maintained as long as the particular fuel is used.

SIZES OF ANTHRACITE USED FOR STEAM GENERATION.

There are four of these sizes, commonly known as "buckwheat" and generally classified as follows:

TABLE 1.

Size of coal.	Size of round mesh over which screened.	Average heat values per pound of coal.
	Inch.	*B. t. u.*
No. 1 Buckwheat	$\frac{5}{16}$	12,250
No. 2 Buckwheat (rice)	$\frac{3}{16}$	12,000
No. 3 Buckwheat (barley)	$\frac{3}{32}$	11,500
No. 4 Buckwheat	$\frac{3}{64}$	11,000
No. 5 Buckwheat	$\frac{3}{128}$	10,000

The curves (fig. 1) give the approximate British thermal units per pound of anthracite of known ash content.

A mixture of these sizes known to the trade as "boiler fuel" is sometimes used. No. 3 of good quality can be and is burned with excellent efficiency under proper hand-fired conditions. No. 4 is not so suitable for hand-fired furnaces.

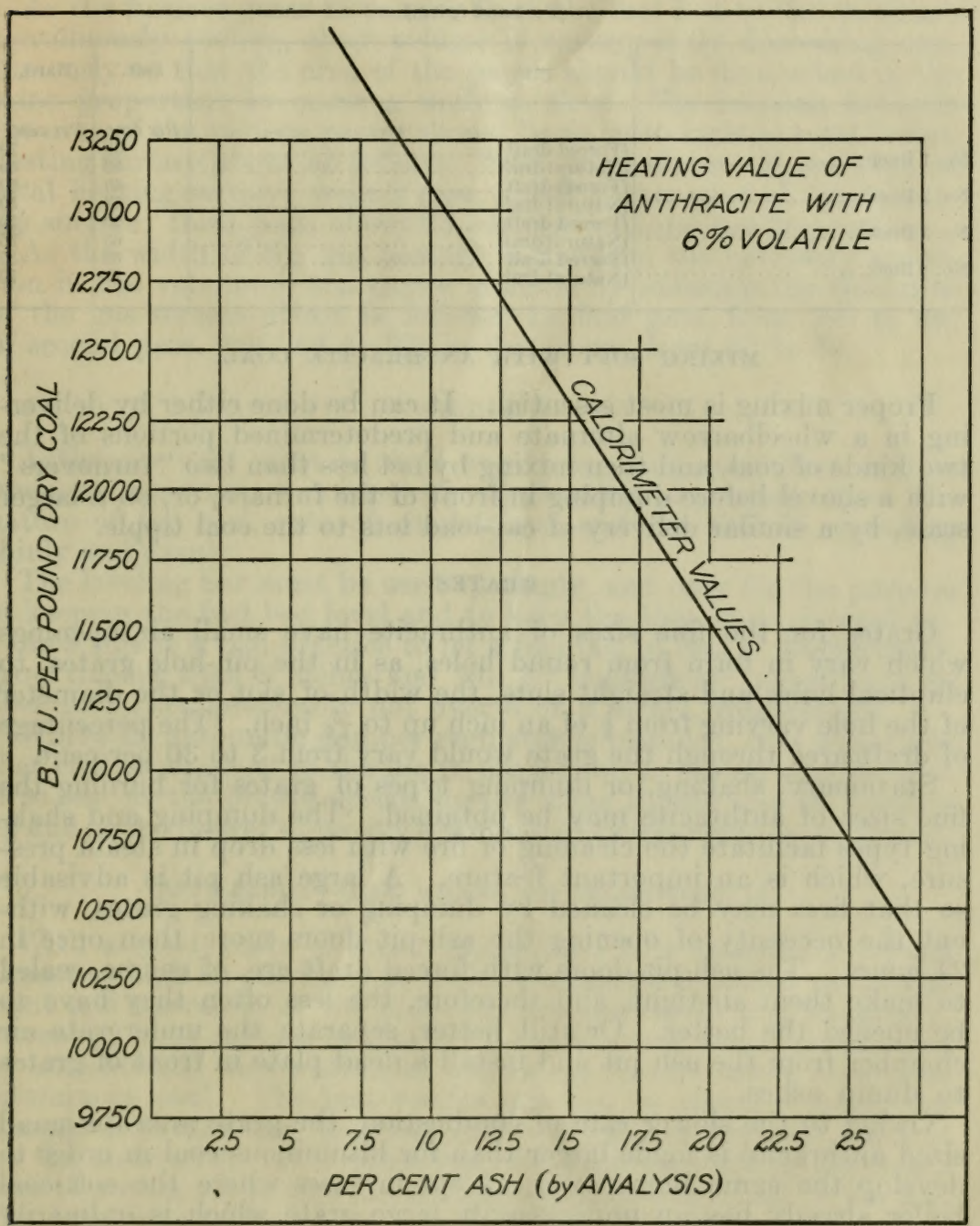
FURNACE EQUIPMENT REQUIRED FOR BURNING VARIOUS PERCENTAGES OF STEAM ANTHRACITE AND SOFT COAL.

1. *Twenty per cent anthracite.*—With ordinary furnace equipment designed for soft coal, up to 20 per cent "buckwheat" or fine sizes of anthracite may ordinarily be burned without any change of equipment or firing practice. Owing to the fact that most boiler furnaces are operated below their normal capacity on soft coal, the above percentage of anthracite can be added without decreasing the capacity of horsepower output of the boiler plant.

2. *Twenty to forty per cent anthracite.*—If a greater percentage of anthracite screenings, 20 to 40 per cent, say, is mixed with the soft coal, it will be necessary, in order to obtain full boiler horsepower, to produce air pressure under the grate. One of the simplest and best methods of obtaining the necessary pressure of one-half to 2 inches in the ash pit, is to install a blower of the turbine type for each boiler. Such a blower may be installed very easily and quickly since it may be fitted into the side wall of the ash pit. It should not use over 3 per cent of the steam developed by the boiler when operating at full capacity. The cost of a steam turbine blower is approximately $200 for a boiler of 150 horsepower or more.

A steam jet blower may be used instead of the steam turbine blower above mentioned. This is cheaper, and the more economical types of steam jet blowers are quite satisfactory in producing the desired results. In purchasing a steam jet blower it is most important to investigate its steam consumption. The best type of these blowers will operate on about the same steam as that required by the turbine blower, whereas the poorer ones may take from two to five times that amount of steam, in which case they should not be installed. The cost of the steam jet blower should be from $50 to $75 or more for a single boiler of 150 horsepower and up. The tur-

bine blower, or the steam jet blower, should be controlled by means of an automatic-draft regulator of the "partial throw" type, in order to obtain efficient results, although fair results are obtainable by hand regulation.



3. *Over 40 per cent anthracite.*—If more than 40 per cent of small anthracite is used the equipment recommended is forced draft plus "buckwheat" grates and a good automatic-draft regulator.

The grates should vary in the matter of diameter of air openings, draft area, and total surface in accordance with the specific fuels used and their proportions in the mixture.

Some plants are able to run efficiently on 100 per cent of a good quality of fine anthracite if properly equipped for this purpose. The table given below furnishes additional data as to mixtures of

various sizes of anthracite and soft coal that may be burned under different conditions of draft.

TABLE 2.—*Proportions of soft and hard coal to be used.*

[For hand firing.]

		Soft.	Hard.
		Per cent.	*Per cent.*
No. 1 Buck	Forced draft	30	70
	Natural draft	40	60
No. 2 Buck	Forced draft	40	60
	Natural draft	50	50
No. 3 Buck	Forced draft	50	50
	Natural draft	65	35
No. 4 Buck	Forced draft	65	35
	Natural draft	80	20

MIXING SOFT WITH ANTHRACITE COAL.

Proper mixing is most essential. It can be done either by delivering in a wheelbarrow alternate and predetermined portions of the two kinds of coal, and then mixing by net less than two "turnovers" with a shovel before dumping in front of the furnace, or, on a larger scale, by a similar delivery of car-load lots to the coal tipple.

GRATES.

Grates for the fine sizes of anthracite have small air openings which vary in form from round holes, as in the pin-hole grates, to elliptical holes and straight slots, the width of slot or the diameter of the hole varying from $\frac{1}{8}$ of an inch up to $\frac{5}{16}$ inch. The percentage of draft area through the grate would vary from 3 to 30 per cent.

Stationary, shaking, or dumping types of grates for burning the fine sizes of anthracite may be obtained. The dumping and shaking types facilitate the cleaning of fire with less drop in steam pressure, which is an important feature. A large ash pit is advisable so that fires may be cleaned by dumping or shaking grates, without the necessity of opening the ash-pit doors more than once in 24 hours. The ash-pit doors with forced draft are, of course, sealed to make them air-tight, and therefore, the less often they have to be opened the better. Or still better, separate the undergrate air chamber from the ash pit and install a dead plate in front of grates to dump ashes.

Owing to the slower rate of combustion, the grate area for small sized anthracite is made larger than for bituminous coal in order to develop the same horsepower, except in cases where the soft-coal boiler already has an unnecessarily large grate, which is ordinarily the case. The relation of the grate area to the heating surface is also of importance. This relation is shown in Table 3.

TABLE 3.—*The relation of grate area to heating surface.*

For No. 1 buckwheat, 1 to 40.	For No. 3 buckwheat, 1 to 30.
For No. 2 buckwheat, 1 to 35.	For No. 4 buckwheat, 1 to 25.

The fuel bed should not be less than 6 feet from any point of the boiler-heating surface.

There should be from 2.5 to 3 cubic feet of combustion space to 1 square foot of grate area.

Another detail of furnace construction which is important is that of the division of the heating surface into the so-called passes.

As the furnace gases in passing from the fuel bed to the stack are continuously cooling, their volume is consequently decreasing continuously so that the area of the passes should be diminished in the same proportion to cause a uniform flow. The relation between the area of the various passes should be so as to include total boiler-heating surface about as follows: First pass, about 43 per cent of total heating surface; second pass, about 32 per cent of total heating surface; third pass, about 25 per cent of total heating surface.

As the width of the gas passage is uniform, the necessary reduction in the volume of the passes is made by reducing the thickness of the gas stream about as follows: In first pass, from 100 to 68; in second pass, from 68 to 52; in third pass, from 52 to 50.

FIRING.

Anthracite coal must be fired evenly in small quantities, and at frequent intervals, the intervals of cleaning depending upon the nature of the coal, rate of combustion, and the skill in spreading thinly and evenly.

The leveling bar must be used sparingly, and only for the purpose of keeping the fuel bed level and to keep the thin spots covered up.

As a rule it is bad practice to let a fuel bed of No. 1 "buckwheat" grow thicker than 8 inches and No. 2 "buckwheat" should not go over 10 inches, preferably not over 6 or 8 inches, respectively.

Where an automatic damper regulator is installed, it is important that coal be supplied to the fire in proportion to the air supply; that is to say, as the blower speeds up the firing should also be speeded up and as the blower slows down the rate of firing should be decreased.

EFFICIENCY—THE MEANS OF PROMOTING IT.

With a good grade of steam anthracite, it is possible to obtain almost as high an efficiency as with bituminous, provided the equipment and operation of the plant are suitable, and very frequently, moreover, large savings in cost of fuel to generate steam are effected by substituting steam sizes of anthracite for the more expensive bituminous coal. The best results can not be obtained unless the changes indicated are made so that the furnace becomes efficient for the anthracite. It is extremely important in burning the steam sizes of anthracite to provide against a large excess of air to the fire. The ideal way to burn this fuel is to use undergrate draft and to throttle the uptake damper to a point where the volume of air will be reduced to a minimum for proper combustion. The necessary pressure for penetrating the bed of fuel is supplied by means of the blower, and the volume is regulated by means of the up-take damper. With this equipment an automatic regulator should be connected for the purpose of controlling the draft in accordance with steam requirements, all of which is ordinary standard equipment which may be obtained for the purpose.

It must be emphasized that the greatest loss in burning the fine anthracite is on account of too much air for the fire, and the principal way to keep this air down to a proper minimum is by using the up-take damper, throttled as much as possible so as to produce the highest Co_2 without the formation of unburned gases. Loss from this source is much less probable than in the case of soft coal, with its high volatile content so that with good installations, the CO_2 may be run at 15 or 16 per cent, under correct supervision and regulation. This percentage of carbon dioxide indicates that practically no more saving can be made by closing the damper still further.

The boiler setting, of course, should be made tight and kept tight. The draft or "suction" over the fire should be kept as low as possible; under ordinary conditions this should run between 0.10 and 0.25 of an inch, water gauge.

SUMMARY.

A boiler plant, designed for soft coal and operating on natural draft is capable of using 20 per cent of steam sizes of anthracite mixed with soft coal without material loss in efficiency, and without change of equipment, provided, sufficient grate surface is available, and this is usually the case. Still higher percentages of fine anthracite may be mixed with the bituminous, provided, certain changes are made in the furnace equipment.

Between 20 and 40 per cent of small-size anthracite may be burned with bituminous, by installing a blower in order to create the necessary draft pressure in the ash pit to penetrate the bed of fuel.

When over 40 per cent of fine anthracite is burned, it becomes necessary or advisable to change to grates of smaller air openings, and also having smaller percentage of draft area and usually of larger total area.

With a given draft pressure or height of stack less horse power will be developed from a boiler which substitutes 100 per cent anthracite for bituminous, unless a blower is installed and the grates changed to suit the new conditions.

The steam sizes of anthracite burn more slowly than bituminous owing partly to the greater resistance to the passage of air through the finer fuel and partly to the very low content of volatile matter in the anthracite; consequently, in order to get the same horsepower out of the boiler, means must be provided to burn the anthracite at a sufficient rate so as to develop the same amount of heat as before with the bituminous. Owing to this slower rate of combustion of small anthracite coal, it is necessary to use a larger grate surface than with bituminous if the boilers are to be run at maximum rating, even when forced draft is applied.

The time has passed forever when efficiency in the use of fuel can be regarded as a matter of choice. You must either save more fuel which you can do easily, or you must continue to lose more money which you will do inevitably and needlessly. You can not pick or choose between these alternatives; you must take one or the other of these ways, for there is no middle course.

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